IMPACT EXPERIMENTS SIMULATING ROCK SAMPLING FROM C-TYPE ASTEROID. C. Okamoto[1], K. Ikezaki[2], N. Imae[3], H. Yano[1], S. Tachibana[4], A. Tsuchiyama[5], H. Sawada[1], S. Hasegawa[1], A.M. Nakamura[6] and T. Tomiyama[7]. [1]Japan Aerospace Exploration Agency, 3-1-1 Yoshinodai, Chuo-Sagamihara, Kanagawa 252-5210, Japan (okamoto.chisato@jaxa.jp), [2]Osaka University, [3]National Institute of Polar Research, [4]Hokkaido University, [5]Kyoto University, [6]Kobe University, [7]JAMSTEC.

Introduction: Hayabusa2 will be launched in 2014 to collect samples from the surface of C-type asteroid, 1999 JU3. C-type asteroids are considered to have more primitive material such as organic matters in comparison to S-type asteroids (e.g., 25143 Itokawa). Reflectance spectrum of 1999 JU3 is compared to be CM chondrites [1]. The sampling is important to clarify the origin of aqueously altered early solar system material and the interactions among minerals, water and organics.

Hayabusa-2 spacecraft has sampling system as well as Hayabusa's "impact sampler." It was designed as a mechanizm suitable for various target surfaces ranging from metal-silicate hard bedrock to regolith layers with gravel [2]. In hayabusa's impact experiments, heat-resistant bricks and glass beads were used as an analog of S-type asteroid's surface. The constituent materials of 1999 JU3 are expected to be fragile in comparison to S-type asteroids. Thus we should investigate the validity of the sampling system onto 1999 JU3 analog materials. Also, impact cratering on the surface of asteroids has been a major factor in the evolution of planetary system. Impact cratering by the sampler is an effective way to understand the cratering mechanizm in micrograviy. It is crucial that we obtain the data of impact experiments in 1G to compare with the outcome in microgravity. Therefore, we conducted impact experiments with carbonaceous chondrite analog targets simulating the sampler system.

Experimental Methods: We prepared sintered glass targets simulated C chondrite as an analog of constituent materials of 1999 JU3. Chondrites mainly have chondrule and host matrix. Thus the targets were configured with 2 sizes of glass beads (~300 μm and ~20 μm) to simulate chondrule and host matrix, respectively [e.g., 3]. The previous data showed that the proprtion of chondrules was 20 ~50 vol% in constituent materials. Thus the targets were prepared with the proportion of large glass beads (~300 μm) of 20 vol% and 50 vol% (Fig. 1). Sintering tempareture were also changed from 610 to 635 to be controlled the tensile strength. We prepared the targets with two different tensile strength (0.1 MPa and 1.5MPa) to investigate the effect of physical properties such as the strength in impact cratering. The values are within the tensile strength of carboneceous chondrites.

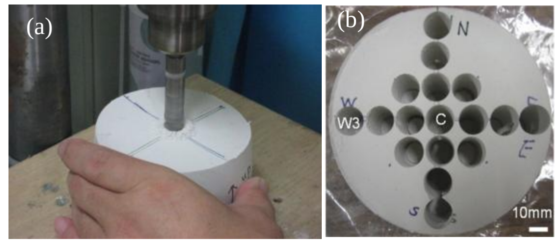

Fig. 1. Photos of coring form the sintered target for measurement of tensile strength. (b) shows the target that was cored from various positions.

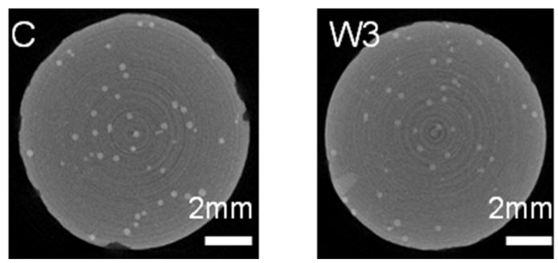

Fig. 2. CT photos of C and W3 in Fig. 1b. The white particles are 300 μm glass beads as an analog of chondrule.We can observe the beads spread evenly in the target.

Impact experiments were conducted using a powder gun at JAXA. The steel projectile was accelerated to velocities of up to 100~200 m/s in the vacuum at 1G. The diameter and mass were 8 mm and 5 g, respectively. They were equivalent in size and mass to the the sampler's projectile. The diameter and height of the target were 100 mm and 60 mm, respectively: In our work, we estimated the impact sampling at monolith (i.e., bedrock). After a shot, we measured the total ejected mass, crater volume and fragment size distributions. The collisional phenomena was also observed by using a high-speed digital video camera at 1×10^4 frames per second.

Results and discussion: We observed impact craters on the targets (Fig. 3). Each one of the targets has spall zone around a central pit. The pit shows cylindrical shape. It is similar to rocky materials such as basalts and bricks. However, the pit size and depth of sintered target are clearly larger than those of rocky materials even at the same impact energy. This is because they depend on the target strength. We also compared the crater shape between the sintered targets with 0.1 MPa and 1.5 MPa at the similar impact energy. The pit diameter of the target with the impact strength of 0.1 MPa is 2~3 times larger than that of 1.5 MPa. Also, the depth is 1.5~2 times deeper than that of 1.5 MPa. Meanwhile, the crater size and depth barely depend on the proportion of 300 μm glass beads in the target. We can recognize the target strength is a important parameter to control the crater size and ejecta volume.

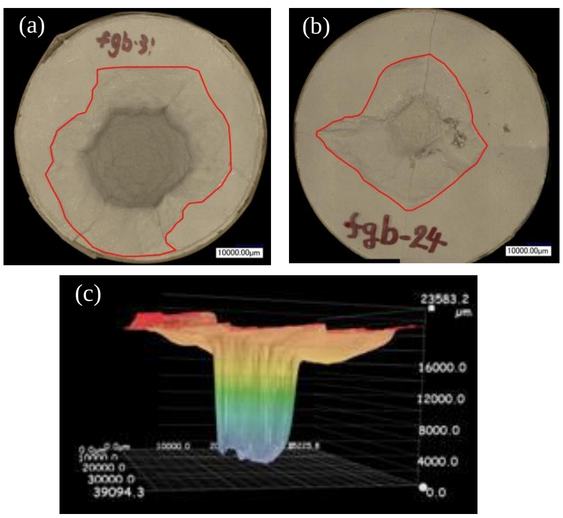

Fig. 3. Crater on sintered targets. They have central pit and spall zone. (a) the target with the impact strength of 0.1 MPa. (b) the target with the impact strength of 1.5 MPa. (c) a 2D image of the cross section for the crater

We also measured the fragment size distributions. The snaps of fragments are shown in Figs. 4a and 4b. The number of fragment pieces for the target of 0.1 MPa is larger than that of 1.5 MPa at the same fragment size. Meanwhile, the proportion of 300 μm glass beads dominates the region of fine fragments (<700 μm): The number of fine fragments increases with the increase of the proportion of chondrules. Thus the fragment size distribution is controlled by the target strength and the proportion of chondrules.

The fragment velocity has been investigated at various positions from an impact site by high speed photography (Figs. 4c and 4d). We observed the difference of outcomes (e.g., the angle of ejecta curtain and fragment velocities) between the different strength. In the case of 0.1 MPa, the ejecta is fluidically ejected because the fragment size is fine whereas we can spot the similarity to brittle targets in the case of 1.5 MPa.

The fragment total mass between the target strength of 0.1 MPa and 1.5 MPa results in differences even at same impact energies. The ejecta mass enhances with the decrease of the target strength, regardless of the proportion of chondrules in the target. We can obtain the relation between fragment total mass and kinetic energy by the following empirical equation by least-square fits;

$$M_t = aE^b \qquad (1)$$

where a and b are the constants. The fragment total mass (M_t) simply increased with an increase of the kinetic energy, E. The power law index (b) of Eq. (1) were approximately 0.8 and 1.5 for the target strength of 0.1 MPa and 1.5 MPa, respectively. The cratering process significantly depends on the target properties, especially target strength.

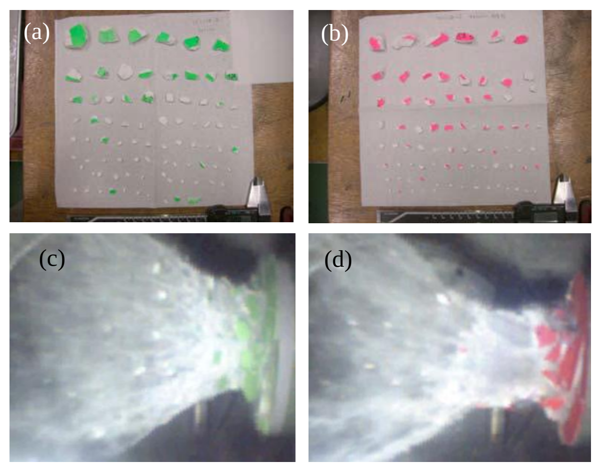

Fig. 4. Fragments ejected from the sintered targets. The proportion of chondrules is 50vol%. The target surface is painted to facilitate visualization. (a) Impact fragments of the target with the strength of 0.1 MPa. (b) Impact fragments of the target with the strength of 1.5 MPa. (c) In-situ observation of cratering for the target with the strength of 0.1 MPa. (d) In-situ observation of cratering for the target with the strength of 1.5 MPa.

References: [1] Vilas F. (2008) *Astronomical Journal, 135*, 1101–1105. [2] Yano H. et al. (2006) *Science, 312*, 1350–1353. [3] Rubin A.E. (2010) *Geochim. Cosmochim. Acta, 74*, 4807-4828.